INTERNATIONAL STANDARD

ISO 22965-2

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Concrete —

Part 2: Specification of constituent materials, production of concrete and compliance of concrete

Béton —

Partie 2: Spécification des matériaux constituants, de la production du béton et de la conformité du béton

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22965-2 was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 3, *Concrete production and execution of concrete structures*.

ISO 22965 consists of the following parts, under the general title *Concrete*:

— *Part 1: Methods of specifying and guidance for the specifier*

— *Part 2: Specification of constituent materials, production of concrete and compliance of concrete*

Introduction

This International Standard is intended for nations that have no national concrete standard and it sets out a framework of principles for nations revising their national standards. To be operable, this International Standard needs a national annex or a reference to the national complementary provisions. This International Standard can also be applied on specific projects where a project specification supplements the standards in lieu of a national annex applicable at the place of use.

This International Standard is applied under various climatic and geographical conditions, various levels of protection and under different established regional traditions and experience. Consequently, this International Standard includes classes for concrete with different properties to cover the most frequent and normal situations. For certain uses of concrete, additional or deviating rules can be necessary. The national provisions, preferably given in a national annex to this International Standard, or the project specification can specify any additional or deviating requirements.

During the development of this International Standard, consideration was given to detailing a performance-related approach to the specification of durability. It was concluded that such an approach is not yet sufficiently developed to be detailed in an International Standard. ISO/TC 71/SC 3 recognizes that some ISO member bodies have developed local tests and criteria for performance-based specifications. This International Standard does not exclude the continuation and development of such practices valid in the place of use of the concrete as an alternative to the prescriptive approach. It is necessary that these requirements be specified in the national annex or national complementary provisions. The Model Code for Service Limit Design (MC-SLD), which was published by *fib* in 2006, is a promising basis for implementation as future International Standards from ISO/TC 71; see ISO 22965-1:2007, Annex B.

This International Standard incorporates rules for the use of constituent materials that are covered by International Standards. For materials for which International Standards have not yet been published, the standards cited in the national annex (often the regional or national standards) apply; see 5.1. In particular, documents in current use for by-products of industrial processes, recycled materials, etc. are based on local experience. Until international specifications for these materials are available, this International Standard does not provide rules for their use, but instead refers to the national annex.

This International Standard defines the two parties involved in the ordering and the supply of concrete, which are hereinafter referred to as specifier and supplier. In practice, there can be several parties specifying requirements at various stages of the design and construction process, e.g. the client, the designer, the quantity surveyor, the constructor and the concreting subconstructor. Each is expected to pass the specified requirements, together with any additional requirements, to the next party in the chain until they reach the supplier. In the terms of this International Standard, this final compilation of requirements is known as the “concrete specification”. In some cases, the specifier and the supplier is the same party (e.g. a constructor doing design, production and execution). In the case of ready-mixed concrete, the purchaser is the specifier.

This part of ISO 22965 also gives rules for the exchange of information between the parties. Contractual matters are not addressed.

This International Standard is intended for use with ISO 22965-1 and with the future ISO 22966, currently under development, which will give the requirements associated with the level of quality specified and the methods to be employed for the execution of concrete structures.

Concrete —

Part 2:
Specification of constituent materials, production of concrete and compliance of concrete

1 Scope

This part of ISO 22965 applies to concrete for structures cast *in situ*, pre-cast structures and structural pre-cast products for buildings and civil engineering structures. The concrete can be mixed on site, ready-mixed concrete or produced in a plant for pre-cast concrete products.

This part of ISO 22965 applies to concrete compacted to retain no appreciable amount of entrapped air other than entrained air and to normal-weight, heavy-weight and light-weight concrete.

Other International Standards for specific products, e.g. pre-cast products, or for processes within the field of the scope of this standard can require or permit deviations from this part of ISO 22965.

This part of ISO 22965 specifies the properties of constituent materials, the production of concrete and the compliance system of concrete.

This part of ISO 22965 does not apply to

— concrete with a maximum aggregate size equal to or less than 4 mm or 5 mm (mortar),

— aerated concrete,

— foamed concrete,

— concrete with an open structure (“no-fine aggregate” concrete),

— concrete with a density less than 800 kg/m^3,

— refractory concrete.

This part of ISO 22965 does not cover health and safety requirements for the protection of workers during production and delivery of concrete.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 680, *Cement — Test methods — Chemical analysis*

ISO 1770, *Solid-stem general purpose thermometers*

ISO 1920-1, *Testing of concrete — Part 1: Sampling of fresh concrete*

ISO 1920-2, *Testing of concrete — Part 2: Properties of fresh concrete*

ISO 1920-3, *Testing of concrete — Part 3: Making and curing test specimens*

ISO 1920-4, *Testing of concrete — Part 4: Strength of hardened concrete*

ISO 1920-5, *Testing concrete — Part 5: Properties of hardened concrete other than strength*

ISO 9297, *Water quality — Determination of chloride — Silver nitrate titration with chromate indicator (Mohr's method)*

ISO 22965-1:2007, *Concrete — Part 1: Methods of specifying and guidance for the specifier*

ASTM C 173, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method

3 Terms and definitions

For the purposes of this part of ISO 22965, the terms and definitions given in ISO 22965-1 and the following apply.

3.1
agitating equipment
equipment generally mounted on a self-propelled chassis and capable of maintaining fresh concrete in a homogeneous state during transport

3.2
all-in aggregate
aggregate comprising a mixture of coarse and fine aggregates

3.3
concrete family
group of concrete compositions for which a reliable relationship between relevant properties is established and documented

3.4
cubic metre of concrete
quantity of fresh concrete which, when compacted, occupies a volume of one cubic metre

3.5
high-strength concrete
concrete with a compressive strength class higher than B50 in the cases of normal-weight or heavy-weight concrete and LB50 in the case of light-weight concrete

NOTE Other limits may be set in the national annex.

3.6
initial test
test or tests before the production starts to check how a new concrete or concrete family shall be composed in order to meet all the specified requirements in the fresh and hardened states

3.7
non-agitating equipment
equipment used for transporting concrete without agitation in the sense of 3.1, e.g. dump truck or transport hopper

3.8
production day
⟨for strength testing⟩
day in which 20 m^3 or more of concrete has been produced or, on days when less than 20 m^3 of concrete has been produced, the day on which a cumulative 20 m^3 of these concretes has been produced

NOTE The sequence is restarted on a new day for each occasion when a production day is counted. Limits other than 20 m^3 may be set in the national annex

3.9
production week
period of seven consecutive days comprising at least five production days or the period taken to complete five production days, whichever is the longer period

3.10
truck mixer
concrete mixer mounted on a self-propelled chassis capable of mixing and delivering a homogeneous concrete

3.11
project specification
project-specific document describing the requirements applicable for the particular project, giving all information and requirements necessary for the execution of the works, including documents, drawings, etc.

NOTE The concrete specification drawn up by the specifier (see ISO 22965-1) should include all relevant requirements for the concrete as given in the project specification.

4 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviations given in ISO 22965-1 and the following apply.

$f_{ck,cyl}$	characteristic compressive strength of concrete determined by testing cylinders, expressed in newtons per square millimetre
$f_{c,cyl}$	compressive strength of concrete determined by testing cylinders, expressed in newtons per square millimetre
$f_{ck,cube}$	characteristic compressive strength of concrete determined by testing cubes, expressed in newtons per square millimetre
$f_{c,cube}$	compressive strength of concrete determined by testing cubes, expressed in newtons per square millimetre
f_{cm}	mean compressive strength of concrete, expressed in newtons per square millimetre
f_{tsm}	mean tensile splitting strength of concrete, expressed in newtons per square millimetre
f_{tsk}	characteristic tensile splitting strength of concrete, expressed in newtons per square millimetre
σ	estimate for the standard deviation of a population
s_n	standard deviation of n consecutive test results
$R_{w/c}$	water/cement ratio
$R_{w/(c,ka)}$	ratio of water to the sum of the cement plus k times the addition, designated as the “effective cementitious material”

5 Requirements for constituent materials

5.1 General

For the use of constituent materials that are covered by International Standards, requirements contained in the International Standards apply. For materials for which there are not yet International Standards, the standards cited in the national annex (often regional or national standards) apply.

Constituent materials shall not contain harmful ingredients in such quantities as can be detrimental to the strength, consistence, setting time and durability of the concrete, or cause corrosion of the reinforcement, and shall be suitable for the intended use in concrete.

Constituent materials that conform to the relevant International Standards cited in this part of ISO 22965 shall be deemed to meet the requirement that they do not contain harmful ingredients in such quantities as can be detrimental to the durability of the concrete or cause corrosion of the reinforcement provided that the concrete conforms to any specified limits placed on it, e.g. maximum chloride content.

Only constituent materials with established suitability for the specified application shall be used in concrete conforming to this part of ISO 22965.

NOTE 1 Where general suitability is established for a constituent material, this does not indicate suitability in every situation and for every concrete composition.

NOTE 2 This part of ISO 22965 lists constituent materials conforming to International Standards that have general suitability. The national annex extends these lists of constituent materials with approved general suitability.

Where types and classes of constituent materials are not detailed in the specification, the producer shall select constituent materials for the specified requirements only.

5.2 Cements

General suitability is established in the national annex for cements conforming to a standard listed in the same annex.

NOTE The following types of cement have characteristics specified in regional and national standards:

— portland cements;

— portland composite cements;

— blast-furnace-slag cements;

— pozzolanic cements;

— composite cements.

Cements can be specified in grades based on the 28-day strength in mortar (e.g. 32,5 MPa, 42,5 MPa and 52,5 MPa), and as normal hardening, rapidly hardening or slowly hardening cements.

5.3 Additions

5.3.1 General suitability is established in the national annex for type I additions of the following types:

— filler aggregate conforming to a standard listed in the same annex;

— pigments conforming to a standard listed in the same annex.

5.3.2 General suitability is established in the national annex for type II additions of the following types:

— fly ash conforming to a standard listed in the same annex;

— silica fume conforming to a standard listed in the same annex;

— ground-granulated blast-furnace slag (GGBS) conforming to a standard listed in the national annex.

5.4 Aggregates

General suitability is established in the national annex for aggregates conforming to a standard listed in the same annex.

The maximum aggregate size shall not be greater than the value specified.

NOTE 1 See the national annex for the test method. Most test methods permit a small proportion of over-sized particles.

Light-weight aggregates shall conform to the following requirements.

a) The acid-soluble sulfate content shall be not more than 0,1 % by mass (see the national annex for the test method);

b) For furnace-bottom ash or clinker, the loss-on-ignition shall be not more than 10 % by mass (see the national annex for the test method).

Where freezing- and thawing-resistant, light-weight aggregates are specified, the producer shall hold data demonstrating that the chosen light-weight aggregates produce concrete with adequate freezing and thawing resistance.

NOTE 2 Freezing and thawing resistance is deemed to be adequate if the aggregates have a successful track record of use for at least 10 years in similar or worse environments with concrete of the quality specified or lower than the quality specified. An alternative method for determining freezing and thawing resistance is by relative freezing and thawing testing of concrete in water or a salt solution, as appropriate. Where this latter method is to be used, it is necessary that the test method and compliance criteria be specified in the national annex.

5.4.1 All-in aggregate

All-in aggregate shall be used only in concrete with compressive strength classes $\leqslant$ B12.

5.4.2 Recovered aggregate

Aggregate recovered from wash water or fresh concrete may be used as aggregate for concrete.

Unless otherwise permitted by the national annex, undivided recovered aggregate shall not be added in quantities greater than 5 % of the total aggregate. Where the quantities of the recovered aggregates are greater than 5 % of the total aggregate, they shall be of the same type as the primary aggregate and shall be divided into separate coarse and fine fractions and shall conform to the aggregate specification.

5.5 Mixing water

General suitability is established in the national annex for mixing water conforming to a standard listed in the same annex.

Recycled water from concrete production shall be used in accordance with the conditions specified for its use in a mixing-water standard of established suitability or in accordance with the provisions given in the national annex.

5.6 Admixtures

General suitability is established in the national annex for admixtures conforming to a standard listed in the same annex.

The total amount of admixtures, if any, should not exceed the maximum dosage recommended by the admixture producer.

Admixtures used in quantities less than 2 g/kg of cement shall be dispersed in part of the mixing water unless otherwise specified in the national annex.

At higher levels of use, the producer may select the method of dispersal.

If the total quantity of liquid admixtures exceeds 3,0 l/m^3 of concrete, its water content shall be taken into account when calculating the water/cement ratio, unless otherwise specified in the national annex.

Where more than one admixture is used, the compatibility of the admixtures shall be checked in the initial tests.

6 Requirements for concrete

6.1 Requirements for composition of concrete

6.1.1 General

The concrete composition and the constituent materials shall be chosen to satisfy the requirements specified for fresh and hardened concrete, including consistence, density, strength, durability and protection of embedded steel against corrosion, taking into account the production process and, if informed, the intended method of execution of the concrete works. Requirements for the use of additions shall be given in the national annex.

Where not detailed in the specification, the producer shall select types and classes of constituent materials from those with established suitability for the specified environmental conditions.

The concrete should be designed so as to minimize segregation and bleeding of the fresh concrete.

6.1.2 Resistance to alkali-aggregate reaction

Deleterious alkali-aggregate reaction shall be avoided using procedures specified in the national annex or the project specification.

6.1.3 Use of additions

The quantities of type I and type II additions used in concrete shall be covered by the initial tests.

The influence of high quantities of additions on properties other than strength should be taken into account.

For designed concrete, the use of additions shall conform to the requirements specified in the national annex or the project specification.

Type II additions conforming to 5.3 may be taken into account when calculating the cement content and the water/cement ratio in accordance with the k-value concept and as permitted by the national annex.

NOTE Informative guidance on the k-value concept is given in Annex F. Other concepts, other k values, other cements, other additions (including type I) or combinations of additions can be given in the national annex.

6.1.4 Chloride content

The chloride content of the concrete shall not exceed the value specified in the national annex or the project specification.

Calcium chloride and chloride-based admixtures shall not be added to concrete containing steel reinforcement, pre-stressing steel reinforcement or other embedded metal.

The method for determining the chloride content of constituent materials is specified in Table 1.

Table 1 — Method for determining the chloride content of constituent materials

Constituent	Method reference
Cement, fly ash, ground-granulated blast-furnace slag (GGBS), limestone fines, pulverized fuel ash (PFA), metakaolin	See national annex
Aggregate	See national annex
Admixture	See national annex
Water [a]	ISO 9297
[a] Testing is not required if the water is from a potable supply.	

For the determination of the chloride content of the concrete, the sum of the contributions from the constituent materials shall be determined using one of, or a combination of, the following methods:

— calculation based on the maximum chloride content of the constituent either permitted in the standard for the constituent or declared by the producer of each constituent material;

— calculation based on the chloride content of the constituent materials calculated monthly from the sum of the means of the last 25 determinations of chloride content plus 1,64 times the calculated standard deviation for each constituent material.

NOTE The latter method is particularly applicable to sea-dredged aggregates and for those cases where there is no declared or standard maximum value.

For the determination of the chloride content of the concrete, the measurement of freshly mixed trial mixtures by means of methods defined in the national annex may be applied.

6.2 Requirements for fresh concrete

6.2.1 Consistence

When measured in accordance with Table 2, the consistence of the concrete at the time of use or, in the case of ready-mixed concrete, at the time of delivery, shall be within the limits given in 9.3.

Where a slump class has been specified, the slump shall be measured to the highest point. Where a target slump has been specified, the slump shall be measured to the highest point except where otherwise specified in the national annex.

Table 2 — Method for measuring consistence

Method	Conforming to
Slump	ISO 1920-2
Slump flow	ISO 1920-2
Flow	ISO 1920-2
Other	To be specified

If concrete is delivered in a truck mixer or agitating equipment, the consistence may be measured using a spot sample obtained from the initial discharge. The spot sample shall be taken after a discharge of approximately 0,1 m^3 in accordance with ISO 1920-1.

Admixtures or water, if permitted by the national annex or the project specification, may be added on site in accordance with a documented procedure and used to bring the consistence to the specified value, provided that the limiting values permitted by the specification are not exceeded and the addition of admixture is considered for the concrete composition. Procedures for the addition of admixtures or water on site may be specified in the national annex. The quantity of any additional admixtures or water added to the truck mixer shall be recorded on the delivery ticket. For remixing, see Clause A.5.

The party who authorizes this addition is responsible for the consequences. The requirements for this authorization shall be provided in the national annex.

6.2.2 Cement content and water/cement ratio

Where the cement, water or addition content is determined, addition content or added water shall be taken either as recorded on the print-out of the batch recorder or, where recording equipment is not used, from the production record in connection with the batching instruction.

The water/cement ratio of concrete shall be calculated on the basis of the determined cement content and the effective water content; see 5.6 for liquid admixtures. The water absorption of normal-weight and heavy-weight aggregates shall be determined in accordance with the method given in the national annex. The water absorption of coarse, light-weight aggregate in the fresh concrete shall be determined in accordance with the method given in the national annex.

For fine light-weight aggregate, the test method and criteria should be specified or declared by the producer.

Where the determination of the cement content, the addition content or water/cement ratio of fresh concrete by analysis is required, the test method and tolerances shall be agreed between the specifier and producer.

The cement content and water/cement ratio shall be within the limits given in 9.3.

6.2.3 Air content

Air content of the concrete shall be measured in accordance with ISO 1920-2 for normal-weight and heavy-weight concrete. For light-weight concrete, it shall be determined in accordance with the method given in the national annex. The air content shall be within the limits given in 9.3.

6.2.4 Concrete temperature

The procedure used to measure the temperature of the fresh concrete shall be one of the following.

a) Within 2 min after taking the sample at delivery, insert a type A 100 mm immersion thermometer, conforming to ISO 1770, into the sample to a depth of not less than 100 mm. When steady conditions have been maintained for 1 min, record the temperature to the nearest 1 °C.

b) Use an alternative form of temperature-measurement device with a precision at least that of a thermometer conforming to ISO 1770 to record the steady-state temperature to the nearest 1 °C.

When measured in accordance with the procedure specified above, the temperature of the fresh concrete at the time of delivery shall not be less than 5 °C or the minimum value specified and shall not exceed any specified upper value.

6.3 Requirements for hardened concrete

6.3.1 Compressive strength

Compressive strength shall be expressed as $f_{c,cyl}$ where determined using cylindrical specimens with a length twice the diameter and $f_{c,cube}$ where determined using cubical specimens, in accordance with ISO 1920-1, ISO 1920-3 and ISO 1920-4. The diameter of the cylinder or the side length of the cube shall be at least three times the maximum aggregate size. In assessing the strength, other curing regimes may be used provided the relationship to those standardized in ISO 1920-3 has been established with sufficient accuracy and has been documented.

The producer shall declare prior to delivery whether the compressive strength is to be assessed on the basis of cylinder or cube tests and the size of the specimen to be used.

Unless otherwise specified, the compressive strength shall be determined on specimens tested at 28 days.

NOTE For particular uses, it can be necessary to specify the compressive strength at ages earlier or later than 28 days (e.g. for massive structural elements) or after storage under special conditions (e.g. heat treatment).

The characteristic strength of the concrete shall be equal to or greater than the minimum characteristic compressive strength for the specified compressive strength class given in Table 3 or 4. For intermediate-strength classes not shown in the table, the minimum characteristic strength shall be obtained by interpolation. Achievement of the minimum characteristic strength may be assumed if the concrete conforms to the compliance criteria for compressive strength given in Clause 9.

Table 3 — Compressive strength classes for normal-weight and heavy-weight concrete

Compressive strength class	Minimum characteristic cylinder strength $f_{ck,cyl}$ N/mm^2	Minimum characteristic cube strength [a] $f_{ck,cube}$ N/mm^2
B8	8	10
B12	12	15
B16	16	20
B20	20	25
B25	25	30
B30	30	37
B35	35	45
B40	40	50
B45	45	55
B50	50	60
B55	55	67
B60	60	75
B70	70	85
B80	80	95
B90	90	105
B100	100	115
B110	110	130
B120	120	140

[a] Other values may be used if the relationship between these and the reference cylinder strength is established with sufficient accuracy and is documented.

Table 4 — Compressive strength classes for light-weight concrete

Compressive strength class	Minimum characteristic cylinder strength $f_{ck,cyl}$ N/mm^2	Minimum characteristic cube strength [a] $f_{ck,cube}$ N/mm^2
LB8	8	9
LB12	12	13
LB16	16	18
LB20	20	22
LB25	25	28
LB30	30	33
LB35	35	38
LB40	40	44
LB45	45	50
LB50	50	55
LB55	55	60
LB60	60	66
LB70	70	77
LB80	80	88

[a] Other values may be used if the relationship between these and the reference cylinder strength is established with sufficient accuracy and is documented.

6.3.2 Tensile splitting strength

The tensile splitting strength of concrete shall be measured in accordance with ISO 1920-4. Unless otherwise specified, the tensile splitting strength shall be determined on specimens tested at 28 days.

The characteristic tensile splitting strength of the concrete shall be equal to or greater than the specified characteristic tensile splitting strength. This may be assumed if the concrete conforms to the compliance criteria for tensile splitting strength given in Clause 9.

6.3.3 Density

For normal-weight concrete, the oven-dry density shall be greater than 2 000 kg/m^3 and not exceed 2 600 kg/m^3. Other limits may be set in the national annex. When determining the compliance of light-weight or heavy-weight concrete to the target density, the density determination of hardened light-weight concrete shall be in accordance with ISO 1920-5 and for either

a) oven-dry condition, or

b) condition specified.

The measured density shall be within the limits given in Clause 9.

6.3.4 Resistance to water penetration

When test specimens are tested for resistance to water penetration, the method and compliance criteria shall be specified.

In the absence of an acceptable test method, resistance to water penetration may be specified indirectly by limiting values for concrete composition.

6.3.5 Reaction-to-fire

Concrete, which is composed of natural aggregates conforming to 5.4, cement conforming to 5.2, admixtures conforming to 5.6, additions conforming to 5.3 or other inorganic constituent materials conforming to 5.1, is designated as a class that does not require a reaction-to-fire test.

7 Production control of concrete

7.1 General

All concrete shall be subjected to a documented production-control system under the responsibility of the producer.

Production control shall be comprised of all measures necessary to maintain the properties of concrete in compliance to specified requirements, including

— selection of materials,

— concrete mix design,

— concrete production,

— inspections and tests,

— use of the results of tests on constituent materials, fresh and hardened concrete and equipment,

— where relevant, inspection of equipment used in transporting fresh concrete.

These requirements shall be appropriate for the kind and size of the production, the works, the particular equipment, the procedures and the rules specified in the national annex.

The production-control system should take account of the principles of a quality management system, such as ISO 9001.

NOTE Guidance on a “benchmark” production-control system is given in Annex A.

7.2 Production-control systems

The responsibility, authority and the interrelation of all personnel who manage, perform and verify work affecting the quality of the concrete shall be defined in a documented production-control system (production-control manual).

NOTE This particularly concerns personnel who need the organizational freedom and authority to minimize the risk of non-conforming concrete and to identify and record any quality problem.

The production-control systems shall be specified in a national annex in a combination of compliance controls and compliance criteria.

When a producer fails to comply with any requirement for the production process and production control, the producer shall investigate the consequences of the non-compliance. When this results in a non-compliance with respect to Clause 9 or the requirements placed on the concrete, the producer shall declare the concrete as non-conforming. In all cases, the cause of non-compliance with the requirements for the production process and production control shall be investigated and corrected without delay.

7.2.1 Requirements for the production-control system — Compliance based on option A

The production-control system where compliance is based on option A (see 9.4.2) shall conform to Clause 9 and any additional requirements placed on the concrete in the project specification. In option A, production shall be kept in a state of statistical control.

7.2.2 Requirements for the production-control system — Compliance based on option B

Where compliance is based on the concept of concrete families corresponding to option B (see 9.4.3), the sampling and testing for production control of normal-weight and heavy-weight concrete of strength classes from B8 to B50 or light-weight concrete from LB8 to LB50 shall be performed either on individual concrete compositions or, preferably, on concrete families of established suitability, as determined by the producer. Light-weight concrete and self-compacting concrete shall not be mixed into families containing normal-weight concrete. Light-weight concretes with demonstrably similar aggregates may be grouped into their own family.

Where more than one concrete is produced, it is recommended that they are formed into families for the purpose of production control, as this can significantly shorten the time between the occurrence of a change and its detection.

NOTE 1 For guidance for the selection of concrete families, see Annex B.

In the case of concrete families, the producer shall assume control over all family members and sampling shall be carried out across the whole range of concrete compositions produced within the family.

NOTE 2 For production control using a concrete family, a reference concrete is selected representing either the most commonly produced composition or one from the mid-range of the concrete family. Relationships are established between each individual concrete composition of the family and the reference concrete in order to be able to normalize test results for compressive strength from each individual concrete test result to the reference concrete.

The relationships between family members shall be reviewed on the basis of original compressive strength test data at every assessment period.

Where compliance is based on option B (see 9.4.3), the production-control system shall have the following characteristics unless otherwise specified in the national annex:

— system for predicting 28 day strength from earlier strength testing and the use of these data until the actual 28 day strengths are determined;

— continual monitoring of the achieved mean strength, standard deviation and the correlation between the early strength and 28 day strength data;

— target mean strength set at a level $\geqslant (f_{ck} + 2\sigma)$;

— assumed minimum standard deviation of 3,0 N/mm^2 ;

— initial estimate of the population standard deviation for a concrete or concrete family is based on at least 35 results taken over a period not exceeding 12 months;

— system with a sensitivity capable of detecting real changes in mean strength $\leqslant 0{,}5\sigma$ over an average run length of 35 results and of detecting real changes in standard deviation equivalent to, or better than, the following:

$$0{,}63\ \sigma \leqslant s_{15} \leqslant 1{,}37\sigma$$

Where the actual mean strength is more than $0{,}5\sigma$ below the target mean strength, the mix proportions shall be adjusted to achieve the target value.

Where $s_{15} > 1{,}37\sigma$, a new design value of standard deviation shall be adopted and the mix proportions adjusted accordingly.

NOTE 3 The requirements for production control given above are sufficient to ensure a very high probability of achieving the specified characteristic strengths over the assessment period and consequently further compliance checking is not necessary. Individual batches are required to be assessed using the criteria given in 9.3 and, for particularly critical lots, identity testing can be applied to confirm that the concrete comes from a conforming population.

Where the actual mean strength is shown to be higher than the target mean strength or the actual standard deviation is lower than the current value, changes to the mix proportions are optional.

7.3 Testing

The testing shall be performed in accordance with

— the test methods given in this part of ISO 22965 (reference test method),

— other test methods if the correlation or safe relationship between the results of these test methods and the reference methods have been established.

The correctness of the safe relationship or correlation shall be examined at appropriate intervals. The examination shall be carried out separately for each place of production that is operated under different conditions unless the relationship is given in the national annex.

8 Delivery of fresh concrete

8.1 Delivery ticket for ready-mixed concrete

At delivery, the supplier shall provide a delivery ticket for each delivery of concrete on which is printed, stamped or written at least the following information:

— name of the ready-mixed concrete plant;

— serial number of the ticket;

— date and time of loading, i.e. time of first contact between cement and water;

— truck number or vehicle identification;

— name of user or purchaser;

— name and location of the site;

— details or references to specifications, e.g. code number, order number;

— amount of concrete in cubic metres;

— declaration of compliance with reference to the specifications;

— name or mark of the certification body, if relevant;

— time at which the concrete arrives on site;

— time of the beginning of unloading;

— time of the end of unloading;

— strength class;

— designation, if used;

— chloride content, if specified;

— consistence class or target value;

— limiting values of concrete composition, if specified;

— type of cement;

— type of admixture and addition, when used;

— special properties, if specified;

— maximum aggregate size;

— target density in the case of light-weight or heavy-weight concrete;

— strength class of the cement in the case of prescribed concrete.

8.2 Delivery information for site-mixed concrete

Appropriate information as required in 8.1 for the delivery ticket is also relevant for site-mixed concrete where the site is large or several types of concrete are involved or where the party producing the concrete is different from the party who is responsible for placing the concrete.

8.3 Transport of concrete

8.3.1 Transport to the point of delivery

Concrete shall be transported in

a) a truck mixer or agitator, or

b) a non-agitating vehicle where permitted by the specifier.

Where non-agitating vehicles are used, procedures shall be followed that have been proven to minimize

— loss of consistence;

— segregation;

— any change in entrained air content, except for the case where the loss of air has been taken into account;

— loss of any constituent;

— ingress of foreign matter or water.

8.3.2 Time of transport

Concrete shall be delivered while fresh and with fresh properties that meet the specified requirements. Concrete should, unless admixtures are used to extend the initial setting time, be delivered within 2,5 h after the time of mixing where transported in truck mixers or agitators or within 1,5 h after the time of mixing where non-agitating equipment is used, unless a shorter time is specified or a longer time permitted by the specifier.

NOTE A longer time after loading can be appropriate in cool, humid weather or when certain types of additions, e.g. ground-granulated blast-furnace slag (GGBS), fly ash or retarding admixtures, are used. A shorter time can be essential in hot weather with cement-rich concretes or where accelerating admixtures have been used.

9 Compliance control and compliance criteria

9.1 General

The compliance or non-compliance is judged against the compliance criteria. Non-compliance can lead to further action at the place of production and on the construction site.

Where tests for production control are the same as those required for compliance control, they are permitted to be used for the verification of compliance.

9.2 Sampling and testing plan

The place of sampling for compliance tests shall be chosen such that the relevant concrete properties and concrete composition do not change significantly between the place of sampling and the place of delivery. In the case of light-weight concrete produced with unsaturated aggregates, the samples shall be taken at the place of delivery.

Samples of concrete shall be randomly selected and taken in accordance with ISO 1920-1. Sampling shall be carried out on concrete produced under conditions that are deemed to be uniform.

The minimum rate of sampling and testing of concrete shall be in accordance with a national annex or a reference to where national complementary provisions are given. If the national annex or the reference does not give a minimum test rate, the recommended values given in Table 5 shall be used as appropriate. The volume of production that constitutes a production day shall be defined in the national annex or, where not defined, the volume shall be 20 m^3; see 3.8.

The samples shall be taken after any water or admixtures are added to the concrete under the responsibility of the producer; however, sampling before adding plasticizer or super-plasticizer to adjust the consistence is permitted when initial testing has proven that the addition of plasticizer or super-plasticizer in the quantity used has no negative effect on either the strength or, where appropriate, the air content of the concrete; see 6.2.1.

The test result shall be that obtained from an individual specimen or the average of the results when two or more specimens made from one sample are tested at the same age. Where two or more test specimens are made from one sample and the range of the test values is more than 15 % of the mean, the results shall be disregarded unless an investigation reveals an acceptable reason to justify disregarding an individual test value.

Table 5 — Recommended minimum rate of sampling for assessing compliance of compressive strength

Method of production assessment	Minimum rate of sampling [a, b, c]		
	First 50 m^3 of production	Production subsequent to first 50 m^3	
		Concrete with production-control certification	Concrete without production-control certification
Option A	3 samples	1 per 200 m^3 or 2 per production week	1 per 150 m^3 or 1 per production day
Option B	Not applicable	1 per 400 m^3 or 1 per production week	

[a] Sampling shall be distributed throughout the production and shall not be more than 1 sample within each 25 m^3.

[b] 28-day strength test data obtained for production control shall also be used to assess compliance.

[c] The minimum test rate is the value that gives the higher rate of sampling.

9.3 Compliance of an individual batch or load

The compliance criteria for an individual batch may be given in the national annex; if criteria are not given in the national annex, Tables E.1 to E.4 shall be used.

The producer, if he detects a non-conforming batch, shall inform the user.

9.4 Compliance over an assessment period

9.4.1 General

The production shall be assessed using either option A (see 9.4.2) or option B (see 9.4.3).

9.4.2 Option A — Compliance criteria

9.4.2.1 Option A applies to continuous production when the production-control system conforms to the requirements in 7.2.1. Option A also applies to initial production, i.e. when fewer than 35 results are available for an individual concrete.

The use of concrete families for compliance using option A is limited to cases when it is the precursor to the application of option B. See 7.2.2 for the limitations on the concrete family.

9.4.2.2 Where the compressive strength, f_{ck}, is specified, the mean compressive strength, f_{cm}, of each group of three non-overlapping results shall be as given in Equation (1):

$$f_{cm} \geqslant (f_{ck} + \delta_c) \quad (1)$$

where δ_c

a) is a value specified in the national annex,

b) is a value specified in the provisions valid at the place of use, or

c) is an assigned value of 4 N/mm^2 if not specified as in 9.4.2.2 a) or b).

9.4.2.3 Where the tensile splitting strength, f_{tsk}, is specified, the mean tensile splitting strength, f_{tsm}, of each group of three non-overlapping results shall be as given by Equation (2):

$$f_{tsm} \geqslant (f_{tsk} + \delta_t) \quad (2)$$

where δ_t

a) is a value specified in the national annex,

b) is a value specified in the provision valid at the place of use, or

c) is an assigned value of 0,5 N/mm^2, if not specified as in 9.4.2.3 a) or b).

9.4.2.4 Where the producer undertakes the compliance control, he shall inform the specifier as soon as practicable when non-compliance is detected.

9.4.3 Option B — Compliance criteria

Option B applies to initial production and continuous production where the production-control system conforms to the requirements in 7.2.2.

There are no additional compliance requirements for an assessment period other than those for an individual batch.

NOTE 1 With option B, third-party certification is recommended or an equivalent level of independent control.

NOTE 2 A specifier who wishes to independently check if a series of batches comes from a conforming population can refer to ISO 22965-1:2007, Annex C.

10 Evaluation of compliance

10.1 General

Unless specified otherwise, the producer shall carry out the evaluation of compliance for specified requirements of the concrete to verify that the claims made for the concrete, e.g. on the delivery ticket, are valid. For this purpose, the following tasks shall be performed:

a) initial tests, where required;

b) compliance control; see Clause 9;

c) for option A, verification that the process is under a state of statistical control.

For pre-cast concrete products, the requirements and provisions for the evaluation of compliance shall be given in the relevant technical specifications (product standards and technical approvals).

10.2 Assessment, surveillance and certification of production control

Where required in the project specification or by the national annex that the producer's production control shall be assessed and surveyed by an approved inspection body and then certified by an accredited certification body, the provisions for assessment, surveillance and certification given in Annex C apply.

Annex A
(informative)

Guidance on a “benchmark” production-control system

A.1 Recorded data and other documents

The production-control system should be reviewed at least every two years by the management of the producer to ensure the suitability and effectiveness of the system. Records of such reviews should be retained for at least three years unless legal obligations require a longer period.

All relevant data from the production control should be recorded, see Table A.1. The records of the production control should be retained for at least three years unless legal obligations require a longer period.

Table A.1 — Recorded data and other documents, where relevant

Subject	Recorded data and other documents
Specified requirements	Contract specification or summary of requirements
Cements, aggregates, admixtures, additions	Name of suppliers and sources
Tests on mixing water (not required for potable water)	Date and place of sampling Test results
Tests on constituent materials	Date and test results
Composition of concrete	Concrete description Record of masses of constituents in batch or load (e.g. cement content) Water/cement ratio Chloride content Code of family member, if adopted
Tests on fresh concrete	Date and place of sampling Location in structure, if known Consistence (method used and results) Density, where required Concrete temperature, where required Air content, where required Volume of concrete batch or load tested Number and codes of specimens to be tested Water/cement ratio, where required
Tests on hardened concrete	Date of testing Code and ages of specimens Test results for density and strength Special remarks (e.g. unusual failure pattern of specimen)
Evaluation of compliance	Compliance/non-compliance with specification

Table A.1 (continued)

Subject	Recorded data and other documents
Additionally for ready-mixed concrete	Name of purchaser Location of work, e.g. the construction site Numbers and dates of delivery tickets related to tests Delivery tickets
Additionally for pre-cast concrete	Additional or different data may be required by the relevant product standard

A.2 Concrete composition and initial testing

A.2.1 General

In the case of using a new concrete composition, initial testing should be performed to provide a concrete that achieves the specified properties or intended performance with an adequate margin. Where long-term experience with a similar concrete (for example, a concrete family) is available, initial testing is not required. The concrete design and design relationships should be re-established when there is a significant change in constituent materials. No initial testing by the producer is necessary in the case of a prescribed concrete or a standardized prescribed concrete.

New concrete compositions obtained by interpolation between known concrete compositions or extrapolations of compressive strength not exceeding 5 N/mm^2 are deemed to satisfy the requirements for initial testing.

Concrete compositions should be reviewed periodically to provide assurance that all concrete designs are still in accordance with the actual requirements, taking account of the change in properties of the constituent materials and the results of production and/or compliance testing on the concrete compositions.

A.2.2 Initial testing procedure

The initial test should establish a concrete that satisfies all specified requirements for fresh and hardened concrete. Where the producer or specifier can demonstrate an adequate design based on data from previous tests or long-term experience, this may be considered as an alternative to initial tests.

NOTE Initial tests are the responsibility of the producer for designed concrete, the specifier for prescribed concrete and the standardization body for standardized prescribed concrete.

Initial tests should be performed before using a new concrete or concrete family.

Initial tests should be repeated when there is a significant change either in the constituent materials or in the specified requirements on which the previous tests were based.

A.2.3 Test conditions

In general, initial tests should be carried out on fresh concrete at a temperature of 15 °C to 22 °C.

If concreting on site is done under widely divergent temperature conditions, or if heat treatment is applied, the producer should be informed of any effects concerning the properties of the concrete and the need for any additional tests.

For the initial test of a single concrete, at least three specimens from each of three batches should be tested. Where the initial test is for a concrete family, the number of concretes to be sampled should encompass the composition range of the family. In this case, the number of batches per concrete may be reduced to one.

The strength of a batch should be taken to be the average of the test results. The result of the initial test on the concrete is the average strength of the batches.

The time between mixing and consistence testing and the results should be recorded.

A significantly higher number of tests is necessary for prescribing the composition of a standardized prescribed concrete to encompass all the permitted constituent materials that are foreseen to be used on a national level. The results of the initial tests should be documented at the responsible standardization organization.

A.2.4 Criteria for adoption of initial tests

For assessing the properties of concrete, in particular those of fresh concrete, the differences between the type of mixer and mixing procedure applied during the initial test and those applied during actual production should be taken into account.

The compressive strength of the concrete with the composition to be adopted for the actual case should exceed the values f_{ck} of Table 3 or 4 by an adequate margin. The margin should be at least twice the expected standard deviation.

The criterion for adoption of initial tests for standardized prescribed concrete based on the mean compressive strength, f_{cm}, expressed in newtons per square millimetre, is given in Equation (A.1):

$$f_{cm} \geqslant f_{ck} + \alpha_a \tag{A.1}$$

where α_a

— is a value that should be specified in a national annex, or

— is the value of 12 if no value is given in the national annex.

The consistence of the concrete should be within the limits of the consistence class at the time at which the concrete is likely to be placed or, in the case of ready-mixed concrete, delivered.

For other properties that are specified, the concrete should meet the specified values with an appropriate margin

A.3 Personnel, equipment and installation

A.3.1 Personnel

Knowledge, training and experience of personnel involved in production and production control should be appropriate to the type of concrete, e.g. high-strength concrete, light-weight concrete.

Appropriate records of the training and experience of the personnel involved in production and production control should be maintained.

NOTE In some countries, there are special requirements regarding the level of knowledge, training and experience for the different tasks.

A.3.2 Equipment and installation

A.3.2.1 Storage of materials

Constituent materials should be stored and handled so that their properties do not change significantly, e.g. by action of climate, intermingling or contamination, and that the compliance with the respective standard is maintained.

Silos should be constructed from such materials and in such a manner as are known to produce a weatherproof container, and should permit free flow and efficient discharge of their contents. Each silo should be fitted with an independent filter, cleaned at regular intervals as defined in the producer's production-control manual, or another method of dust control sufficient to allow the delivery to be maintained at the correct pressure shoud be used.

NOTE It is important to ensure that the silo remains weatherproof throughout its working life.

The producer should take precautions to ensure that bagged cement does not become damp either from the weather or from the ground. The store should be managed so that the cement is used in the same order as it is delivered.

Cement that has been adversely affected by damp or other causes should not be used.

Storage compartments should be clearly marked in order to avoid errors in use of the constituent materials.

Special instructions from the suppliers of the constituent materials should be taken into account.

Facilities should be provided to enable representative samples to be taken, for example, from stockpiles, silos and bins.

A.3.2.2 Batching equipment

The performance of the batching equipment should be such that under practical conditions of operation the tolerances stated in Clause A.4 can be obtained and maintained.

The accuracy of the weighing equipment should conform to the accuracy requirements valid at the place of production of the concrete.

A.3.2.3 Mixers

The mixers should be capable of achieving a uniform distribution of the constituent materials and a uniform consistence of the concrete within the mixing time and at the mixing capacity.

Truck mixers and agitating equipment should be so equipped as to enable the concrete to be delivered in a homogeneous state. In addition, the truck mixers should be provided with suitable measuring and dispensing equipment if water or admixtures are to be added on site.

A.3.2.4 Testing equipment

All necessary facilities, equipment and instructions for its proper use should be available when required for inspections and tests on equipment, constituent materials and concrete.

Relevant test equipment should be in calibration at the time of testing and the producer should operate a calibration programme.

A.4 Batching of constituent materials

A documented batching instruction giving details of the type and quantity of the constituent materials should be available at the place of batching of the concrete. Where batching is electronically controlled, the documented batching instruction should be held at the controlling office.

The tolerance of batching constituent materials should not exceed the limits given in Table A.2 for all quantities of concrete of 1 m^3 or more, unless other values are given in the national annex.

Table A.2 — Recommended tolerances for the batching process of constituent materials

Constituent material	Tolerance [a]
Cement Water Total aggregates Additions used at ± 5 % by mass of cement	± 3 % of required quantity
Admixtures and additions used at ⩽ 5 % by mass of cement	± 5 % of required quantity

[a] The tolerance is the difference between the target value and the measured value.

Cements, aggregates and additions in the form of powders should be batched by mass; other methods are permitted if the required batching tolerance can be achieved and this is documented.

The mixing water, admixtures and liquid additions may be batched by mass or by volume.

A.5 Mixing of concrete

Mixing of the constituent materials should be carried out in a mixer conforming to A.3.2.3 and be continued until the concrete is of uniform appearance. Mixers should not be loaded in excess of their rated mixing capacity.

Admixtures, where used, should be added during the main mixing process, except for high-range water-reducing admixtures or water-reducing admixtures that may be added after the main mixing process. In the latter case, the concrete should be remixed until the admixture has been completely dispersed throughout the batch or load and has become fully effective.

For light-weight concrete batched with unsaturated aggregates, the period from initial mixing to the end of final-mixing (e.g. remixing in a truck mixer) should be continued until the water absorption of the aggregates and subsequent evacuation of air from the light-weight aggregates does not have any significant negative impact on the concrete properties.

The composition of the fresh concrete should not be altered after leaving the mixer.

A.6 Production-control procedures

The constituent materials, equipment, production procedures and concrete should be controlled with regard to their compliance with the specifications and the requirements of this part of ISO 22965. The control should be such that significant changes that influence the properties are detected and appropriate corrective action taken.

The types and frequency of inspections/tests for constituent materials should be as given in Table A.3.

Table A.3 is based on the assumption that there is adequate production control by the producer of the constituent materials at the places where the materials are produced and that the constituent materials are delivered with a declaration or a certificate of compliance with the relevant specification. If not, the producer of the concrete should check the compliance of the materials to the relevant standards.

The control of equipment should ensure that the storage facilities, the weighing and gauging equipment, the mixer and control apparatus (e.g. for measuring water content of the aggregates) are in good working condition and that they conform to the requirements of this part of ISO 22965. Frequency of inspections and tests for equipment (where used) are given in Table A.4.

Plant, equipment and transportation facilities should be subjected to a planned maintenance system and shall be maintained in efficient working condition so that the properties and the quantity of concrete are not adversely affected.

The properties of designed concrete should be controlled to the requirements given in Table A.5.

The proportions of prescribed concrete, its consistence and temperature where specified, should be controlled to the requirements given in Table A.5, lines 2 to 4, 6, 7 and 9 to 14.

The control should include production, transportation to the point of delivery and delivery.

For some concretes, additional requirements for production control can be necessary. For the production of high-strength concrete, special knowledge and experience are required. Annex D gives some guidance. If the contract has defined special requirements for the concrete, the production control should include appropriate actions in addition to those in Tables A.3 to A.5.

Unless specified otherwise in the national annex, high-strength concrete is defined as concrete with a strength class greater than B50 or LB50; see 3.5.

The actions foreseen in Tables A.3, A4 and A.5 should be adapted to the conditions of the specific production place and, where necessary, be replaced by actions that provide an equivalent level of control.

Table A.3 — Control of constituent materials

Row	Constituent material	Inspection/test	Purpose	Minimum frequency
1	Cements [a]	Inspection of delivery ticket [d] prior to discharge	To ascertain if the consignment is as ordered and from the correct source	Each delivery
2	Aggregates	Inspection of delivery ticket [b,d] prior to discharge	To ascertain if the consignment is as ordered and from the correct source	Each delivery
3		Inspection of the aggregate prior to discharge	For comparison with normal appearance with respect to the grading, shape and impurities	Each delivery Where delivery is by belt conveyor Periodically depending on local or delivery conditions
4		Test by sieve analysis	To assess compliance to the standard or other agreed grading	First delivery from new source where this information is not available from the aggregate supplier In case of doubt following visual inspection Periodically depending on local or delivery conditions [e]
5		Test for impurities	To assess the presence and quantity of impurities	First delivery from new source where this information is not available from the aggregate supplier In case of doubt following visual inspection Periodically depending on local or delivery conditions [e]

Table A.3 (continued)

Row	Constituent material	Inspection / test	Purpose	Minimum frequency
6		Test for water absorption	To assess the effective water content of concrete	First delivery from new source where this information is not available from the aggregate supplier In case of doubt
7	Additional control for light-weight or heavy-weight aggregates	Test for loose bulk density	To measure the loose bulk density	First delivery from new source where this information is not available from the aggregate supplier In case of doubt following visual inspection Periodically depending on local or delivery conditions [e]
8	Admixtures [c]	Inspection of delivery ticket and label on container prior to discharge	To ascertain if the consignment is as ordered and properly marked	Each delivery
9		Tests for identification	For comparison with manufacturer's stated data	In case of doubt
10	Additions [c] bulk powder	Inspection of delivery ticket [d] prior to discharge	To ascertain if the consignment is as ordered and from the correct source	Each delivery
11		Test of loss of ignition of fly ash	To identify changes in carbon content which may effect air-entrained concrete	Each delivery to be used for air-entrained concrete where this information is not available from the supplier
12	Additions in suspension [c]	Inspection of delivery ticket [d] prior to discharge	To ascertain if the consignment is as ordered and from the correct source	Each delivery
13		Test for density	To ascertain uniformity	Each delivery and periodically during production of concrete
14	Water	Test for suitability	To ascertain that the water is free from harmful constituents if the water is not potable.	Where a new non-potable source is used for the first time In case of doubt

[a] It is recommended that samples are taken once per week from each cement type and stored for testing in case of doubt.

[b] The delivery ticket or the product data sheet shall also contain information on the maximum chloride content and should identify classification with respect to alkali silica reaction in accordance with the provisions valid in the place of use of the concrete.

[c] It is recommended that samples are taken at each delivery and stored.

[d] The delivery ticket shall contain, or be accompanied by, a declaration or certificate of compliance as required in the National Annex or the project specification.

[e] This is not necessary where the production control for the aggregate is certified.

Table A.4 — Control of equipment

Row	Equipment	Inspection/test	Purpose	Minimum frequency
1	Stockpiles, bins, etc.	Visual inspection	To ascertain compliance with the requirements	Once per week
2	Weighing equipment	Visual inspection of the performance	To ascertain that the weighing equipment is in a clean condition and functions correctly	Daily
3		Test of weighing accuracy	To ascertain the accuracy according to A.3.2.2	On installation Periodically [a] depending on national provisions In case of doubt
4	Admixture dispensers (including those mounted on truck mixers)	Visual inspection of performance	To ascertain that the measuring equipment is in a clean condition and functions correctly	First use of the day for each admixture
5		Test of accuracy	To avoid inaccurate dispensing	On installation Periodically [a] after installation In case of doubt
6	Water meter	Test of measuring accuracy	To ascertain accuracy according to A.3.2.2	On installation Periodically [a] after installation In case of doubt
7	Equipment for continuous measurement of water content of fine aggregates	Comparison of the actual amount with the reading of the meter	To ascertain accuracy	On installation Periodically [a] after installation In case of doubt
8	Batching system	Visual inspection	To ascertain that the batching equipment is functioning correctly	Daily
9		Comparison (by a suitable method depending on the batching system) of the actual mass of the constituents in the batch with the target mass and, in the case of automatic batch recording, with the recorded mass	To ascertain batching accuracy according to Table A.2	On installation In case of doubt Periodically [a] after installation
10	Testing apparatus	Calibration according to relevant standards	To check the compliance	Periodically [a] For strength testing apparatus, at least once per year
11	Mixers (including truck mixers)	Visual inspection	To check the wear of the mixing equipment	Periodically [a]

[a] The frequency depends on the kind of equipment, its sensitivity in use and the production conditions of the plant.

Table A.5 — Control of production procedures and of concrete properties

Row	Type of test	Inspection/test	Purpose	Minimum frequency
1	Properties of designed concrete	Initial test (see Clause A.2)	To provide proof that specified properties are met by the proposed design with an adequate margin	Before using a new concrete composition
2	Water content of fine aggregates	Continual measuring system, drying test or equivalent	To determine the dry mass of aggregate and the water to be added	If not continual, daily; depending on local and weather conditions, more or less frequent tests may be required
3	Water content of coarse aggregates	Drying test or equivalent	To determine the dry mass of aggregate and the water to be added	Depending on local and weather conditions
4	Water content of fresh concrete	Check of the quantity of water added [a]	To provide data for the water/cement ratio	Every batch
5	Chloride content of concrete	Initial determination by calculation	To ensure that the maximum chloride content is not exceeded	When performing initial test In case of an increase in the chloride content of the constituents
6	Consistence	Visual inspection	For comparison with normal appearance	Every batch
7		Consistence test	To assess the achievement of the specified values of consistence and to check possible changes of water content	Where consistence is specified, as Table 5 for compressive strength When testing air content In case of doubt following visual inspections
8	Density of fresh concrete	Density test according to ISO 1920-2	For light-weight and heavy-weight concrete for supervision of batching and density control	Daily
9	Cement content of fresh concrete	Check the mass of cement batched [a]	To check the cement content and to provide data for the water/cement ratio	Every batch
10	Additions content of fresh concrete	Check the mass of additions batched [a]	To check the additions content and to provide data for the water/cement ratio	Every batch
11	Admixture content of fresh concrete	Check the mass or volume of admixture batched [a]	To check the admixture content	Every batch
12	Water/cement ratio of fresh concrete	By calculation or by test method	To assess the achievement of the specified water/cement ratio	Daily, where specified
13	Air content of fresh concrete, where specified	Test according to ISO 1920-2 for normal-weight and heavy-weight concrete ASTM C 173 for light-weight concrete	To assess the achievement of the specified content of entrained air	For concretes containing entrained air: first batch of each production day until values stabilize

Table A.5 (continued)

Row	Type of test	Inspection/test	Purpose	Minimum frequency
14	Temperature of fresh concrete	Measure temperature	To assess the achievement of the minimum temperature of 5 °C or a specified limit	In case of doubt Where temperature is specified: — periodically, dependent on the situation; — each batch where the concrete temperature is close to the limit
15	Density of hardened light-weight or heavy-weight concrete	Test according to ISO 1920-5 [b]	To assess the achievement of the specified density	Where density is specified, as frequently as compressive strength test
16	Compressive strength test on moulded concrete specimen	Test according to ISO 1920-1, ISO 1920-3 and ISO 1920-4	To assess the achievement of the specified strength	Where compressive strength is specified, as frequently as for compliance control; see Table 5

[a] Where recording equipment is not used and the batching tolerances for the batch are exceeded, record the batched quantity in the production record.

[b] May also be tested in saturated conditions, where a safe relationship to oven-dry density is established.

Annex B
(informative)

Concrete families

B.1 General

This annex provides details on the use of concrete families as indicated in 7.2.2 and 9.4.3.

B.2 Selection of the concrete family

When selecting the family for production and compliance control, the producer shall achieve control over all the family members. Where there is little experience of using the concrete family concept, the following is recommended for a family:

— cement of one type, strength class and source;

— demonstrably similar aggregates and type I additions;

— concretes with or without a water-reducing/plasticizing admixture;

— full range of consistence classes;

— concrete with a limited range of strength classes.

Concretes containing a type II addition, i.e. a pozzolanic or latent hydraulic addition, should be put into a separate family.

Concretes containing admixtures that can have an impact on compressive strength, e.g. high-range water-reducing/super-plasticizing, accelerators, retarding or air-entraining admixtures, should be treated as individual concretes or separate families.

To be demonstrably similar, aggregates should be from the same geological origin, be of the same type, e.g. crushed, and have a similar performance in concrete.

Before using the family concept or extending the families given above, the relationships should be tested on previous production data to prove that they give adequate and effective production and compliance control.

Annex C
(normative)

Provisions for assessment, surveillance and certification of production control

C.1 General

The provisions for assessment, surveillance and certification of production control by an approved body, when required for production or compliance control (see 10.2), are given in this annex.

C.2 Tasks for the inspection body

C.2.1 Initial assessment of the production control

An initial inspection of the concrete plant and its production control shall be performed by the approved inspection body. The initial inspection is for the purpose of determining whether the prerequisites, in terms of staff and equipment for orderly production and for the corresponding production control, appear to be suitable.

The inspection body shall check at least the following:

— producer's production-control manual, assessing its provisions and, in particular, whether it conforms with the requirements for production control in Clause 10 and whether it takes account of the requirements of this part of ISO 22965;

— availability of current documents essential for plant inspections at the relevant places and if these are available to the persons in the plant;

— whether all necessary facilities and equipment are available to carry out the necessary inspections and tests on equipment, constituent materials and concrete;

— qualifications of the staff for production and production control;

— whether initial testing is performed according to Annex A and if this is reported in an adequate manner.

If indirect testing is performed or if compliance for strength is based on the transposed results of the concrete family concept, the producer shall prove the correlation or safe relationship between the direct and indirect testing to the satisfaction of the inspection body.

All the relevant facts from the initial inspection, especially the equipment at the production place, the production-control system and the assessment of the system, shall be documented in an assessment report.

When a production unit has passed the initial inspection to the satisfaction of the inspection body, the inspection body shall issue an assessment report that the production control conforms to Clause 10 of this part of ISO 22965. This report shall be passed to the producer and to the approved certification body.

NOTE On the basis of this report, the approved certification body decides on the certification of the production control; see C.3.1.

C.2.2 Continuous surveillance of the production control

C.2.2.1 Routine inspection

The principal objective of the routine inspection by the inspection body is to check whether the prerequisites for production and agreed production control are being maintained. For this purpose, the assessment report of the initial inspection is used as a statement of the agreed production control.

The producer is responsible for the maintenance of the production-control system. When significant changes are made at the facilities or the production place, to the production-control system or to the production-control manual, the producer shall notify the changes to the inspection body, which may request a re-inspection.

During the routine inspection, the inspection body shall assess at least the following:

— production, sampling and testing procedures;

— recorded data;

— test results obtained for production control during the inspection period;

— that the required tests or procedures have been carried out with appropriate frequency;

— that the production equipment has been maintained as scheduled;

— that the test equipment has been maintained and calibrated as scheduled;

— actions taken with respect to any non-compliance;

— delivery tickets and the declarations of compliance, where relevant.

To provide confidence in the sampling and testing of the producer's production control, the inspection body shall, during the routine inspection, take spot samples from the running production for testing. Sampling for this purpose shall not be announced in advance. The inspection body shall determine the appropriate frequency for each production unit in which testing on the concrete should be conducted, taking account of the individual circumstances.

Designed concretes shall be tested for the specified properties, e.g. strength, consistence. For prescribed concrete, testing shall cover consistence and composition only.

Comparison shall be made between the producer's routine test results and the results of testing by the inspection body.

The inspection body shall periodically examine the correlation between the direct and indirect testing and the relationships between the members of a concrete family.

The results of the routine inspection shall be documented in a report to be passed to the producer and the certification body.

The routine inspections shall be performed at least twice a year, except where the verification or the certification scheme defines conditions for decreasing or increasing that frequency.

C.2.2.2 Extraordinary inspections

An extraordinary inspection is necessary

— if severe discrepancies are detected during a routine inspection (re-inspection),

— when there has been no production for a period of more than six months,

— when requested by the producer, e.g. because of changes in the production conditions,

— giving due justification if requested by the certification body.

The scope, type and timing of the extraordinary inspection depend on the particular situation.

C.3 Tasks for the certification body

C.3.1 Certification of production control

The certification body shall certify the production control on the basis of a report from the inspection body that states the production unit has passed the initial assessment of the production control to the satisfaction of the inspection body.

The certification body shall decide on the further validity of the certificate on the basis of the reports of the continued surveillance of the production control.

C.3.2 Measures in case of non-compliance

Where the inspection body identifies non-compliance with the specification or where defects have been revealed in the production process or in the production control on which the producer has not reacted properly in due time, the certification body shall request that the producer rectify the defects within an appropriately short period. The actions of the producer shall be verified by the inspection body.

If appropriate, an extraordinary inspection and additional tests shall be arranged in the case of non-compliance with

— strength,

— water/cement ratio,

— basic limits on the composition,

— density, where specified for designed light-weight and heavy-weight concrete,

— specified composition in the case of prescribed concrete.

If the results of the extraordinary inspection are not satisfactory or if the additional tests failed the set criteria, the certification body shall suspend or withdraw the certificate of compliance without undue delay.

NOTE After the suspension or the withdrawal of the certificate of the production control, the producer is no longer permitted to refer to the certificate.

In case of other faults, the certification body might not consider an extraordinary inspection necessary and may accept documentary evidence that the fault has been rectified. Such evidence shall be confirmed during the next routine inspection.

Annex D
(informative)

Additional provisions for high-strength concrete

This annex gives some recommendations on provisions for production control additional to those given in Tables A.3, A.4 and A.5 when high-strength concrete is produced.

Numbers for the rows in the following Tables D.1, D.2 and D.3 are related to those in Tables A.3, A.4 and A.5, respectively, and replace or amend the equivalent requirements.

Table D.1 — Control of constituent materials

Row	Material	Inspection/test	Purpose	Minimum frequency
4	Aggregates	Test by sieve analysis or aggregate supplier information	To assess compliance to agreed grading	Each delivery, unless the aggregates are delivered with restricted tolerances and with a certificate of the production control
8a	Admixtures	Test for dry material content	For comparison with the declared value on the data sheet	Each delivery, unless the test data for this delivery are provided by the supplier In case of doubt
8b	Admixtures [a]	Test for density	For comparison with nominal density	Each delivery, unless the test data for this delivery are provided by the supplier
11	Additions bulk powder	Test of loss of ignition	To identify changes in carbon content that may effect the fresh concrete properties	Each delivery, unless the test data for this delivery are provided by the supplier

[a] It is recommended that samples are taken from each delivery and stored.

Table D.2 — Control of equipment

Row	Equipment	Inspection/test	Purpose	Minimum frequency
1	Stockpiles, bins, etc.	Visual inspection	To ascertain compliance with the requirements	Daily
3a	Weighing equipment	Test of weighing accuracy	Confirmation of accuracy at single point	On installation Periodically after installation In case of doubt
5	Admixture dispensers (including those mounted on truck mixers)	Test of accuracy	To achieve accurate dispensing	On installation Periodically after installation In case of doubt
6a	Water meter	Comparison of the measured value with the target value	To ascertain accuracy	On installation Periodically after installation In case of doubt
7	Equipment for continuous measurement of water content of fine aggregates	Comparison of the measured value with the reading of the meter	To ascertain accuracy	On installation Periodically after installation In case of doubt
9	Batching system	Comparison (by a suitable method depending on the batching system) of the measured value of the constituents in the batch with the target value and, in the case of automatic batch recording, also with the recorded value.	To ascertain batching accuracy	On first installation In case of doubt at subsequent installations Monthly after installation

Table D.3 — Control of production procedures and of concrete properties

Row	Type of test	Inspection/test	Purpose	Minimum frequency
3	Water content of the coarse aggregates	Drying test or equivalent	To determine the mass of aggregates and the water to be added	Daily Depending on local and weather conditions, more or less frequent testing may be required
4	Added water content of fresh concrete	Record [a] the quantity of water added	To provide data for the water/cement ratio	Every batch or load
9	Cement content of fresh concrete	Record [a] the quantity of cement added	To check the cement content and to provide data for the water/cement ratio	Every batch or load
10	Additions content of the fresh concrete	Record [a] the quantity of additions added	To check the additions content	Every batch or load

[a] For production of high-strength concrete, automatically recording weighing equipment is recommended.

Annex E
(normative)

Compliance criteria for an individual batch for consistence and properties other than consistence

Compliance criteria for an individual batch for consistence and properties other than consistence should be as given in Tables E.1 to E.4.

Table E.1 — Compliance criteria for slump measured on an individual batch

Type of measurement	Slump	Compliance criteria
Slump classes measured on representative sample	S1	$\leqslant$ 60 mm
	S2	$\geqslant$ 40 mm, $\leqslant$ 110 mm
	S3	$\geqslant$ 90 mm, $\leqslant$ 170 mm
	S4	$\geqslant$ 150 mm, $\leqslant$ 230 mm
	S5	$\geqslant$ 210 mm
Slump classes measured on initial discharge	S1	$\leqslant$ 70 mm
	S2	$\geqslant$ 30 mm, $\leqslant$ 120 mm
	S3	$\geqslant$ 80 mm, $\leqslant$ 180 mm
	S4	$\geqslant$ 140 mm, $\leqslant$ 240 mm
	S5	$\geqslant$ 200 mm
Slump specified as a target value and measured on representative sample	Target slump $\leqslant$ 40 mm	$\geqslant$ Target slump minus 20 mm, $\leqslant$ Target slump plus 30 mm
	Target slump, 50 mm to 90 mm	$\geqslant$ Target slump minus 30 mm, $\leqslant$ Target slump plus 40 mm
	Target slump $\geqslant$ 100 mm	$\geqslant$ Target slump minus 40 mm, $\leqslant$ Target slump plus 50 mm
Slump specified as a target value and measured on initial discharge	Target slump $\leqslant$ 40 mm	$\geqslant$ Target slump minus 30 mm, $\leqslant$ Target slump plus 40 mm
	Target slump, 50 mm to 90 mm	$\geqslant$ Target slump minus 40 mm, $\leqslant$ Target slump plus 50 mm
	Target slump $\geqslant$ 100 mm	$\geqslant$ Target slump minus 50 mm, $\leqslant$ Target slump plus 60 mm

Table E.2 — Compliance criteria for flow diameter measured on an individual batch

Type of measurement	Flow diameter	Compliance criteria
Flow classes measured on representative sample	F1	⩽ 370 mm
	F2	⩾ 330 mm, ⩽ 440 mm
	F3	⩾ 400 mm, ⩽ 510 mm
	F4	⩾ 470 mm, ⩽ 580 mm
	F5	⩾ 540 mm, ⩽ 650 mm
	F6	⩾ 610 mm
Flow classes measured on initial discharge	F1	⩽ 380 mm
	F2	⩾ 320 mm, ⩽ 450 mm
	F3	⩾ 390 mm, ⩽ 520 mm
	F4	⩾ 460 mm, ⩽ 590 mm
	F5	⩾ 530 mm, ⩽ 660 mm
	F6	⩾ 600 mm
Flow specified as a target value and measured on representative sample	All target flow diameters	⩾ Target flow minus 50 mm, ⩽ Target flow plus 60 mm
Flow specified as a target value and measured on initial discharge	All target flow diameters	⩾ Target flow minus 60 mm, ⩽ Target flow plus 70 mm

Table E.3 — Compliance criteria for slump flow diameter measured on an individual batch

Type of measurement	Slump flow diameter	Compliance criteria
Slump flow classes measured on representative sample	SF1	⩾ 370 mm, ⩽ 530 mm
	SF2	⩾ 450 mm, ⩽ 650 mm
	SF3	⩾ 560 mm, ⩽ 750 mm
	SF4	⩾ 660 mm
Slump flow classes measured on initial discharge	SF1	⩾ 360 mm, ⩽ 540 mm
	SF2	⩾ 440 mm, ⩽ 660 mm
	SF3	⩾ 550 mm, ⩽ 760 mm
	SF4	⩾ 650 mm
Slump flow specified as a target value and measured on representative sample	Target slump flow ⩽ 500	⩾ Target slump flow minus 80 mm, ⩽ Target slump flow plus 80 mm
	Target slump flow > 500	⩾ Target slump flow minus 100 mm, ⩽ Target slump flow plus 100 mm
Slump flow specified as a target value and measured on initial discharge	Target slump flow ⩽ 500	⩾ Target slump flow minus 90 mm, ⩽ Target slump flow plus 90 mm
	Target slump flow > 500	⩾ Target slump flow minus 110 mm, ⩽ Target slump flow plus 110 mm

Table E.4 — Compliance criteria for an individual batch for properties other than consistence

Property	Compliance criteria
Compressive strength	⩾ Specified characteristic compressive strength minus 4, expressed in newtons per square millimetre
Tensile splitting strength	⩾ Specified characteristic tensile splitting strength minus 0,5, expressed in newtons per square millimetre
Flexural strength	⩾ Specified characteristic flexural strength minus 0,5, expressed in newtons per square millimetre
Density of heavy-weight concrete	⩾ Specified target density minus 130, expressed in kilograms per cubic metre ⩽ Specified target density plus 300, expressed in kilograms per cubic metre
Density of light-weight concrete	⩾ Specified target density minus 130, expressed in kilograms per cubic metre ⩽ Specified target density plus 130, expressed in kilograms per cubic metre
Water/cement ratio	Specified as a maximum water/cement ratio: ⩾ Specified maximum water/cement ratio plus 0,02
	Specified as a target water/cement ratio: ⩾ Specified target water/cement ratio minus 0,04 ⩽ Specified target water/cement ratio plus 0,04
Cement content	Specified as minimum cement content: ⩾ Specified minimum cement content minus 10, expressed in kilograms per cubic metre
	Specified as a target cement content: ⩾ 97 % of the specified target cement content ⩽ 103 % of the specified target cement content
Air content of air-entrained fresh concrete	⩾ Specified minimum air content minus 0,5, expressed in percent ⩽ Specified minimum air content plus 5,0, expressed in percent
Chloride content	⩽ Specified maximum chloride content
Concrete temperature	⩾ Specified minimum temperature ⩽ Specified maximum temperature

Annex F
(informative)

Guidance for the use of the k-value concept

F.1 General

The k-value concept permits type II additions to be taken into account

— by replacing $R_{w/c}$, the water-to-cement ratio, by $R_{w/(c,ka)}$, the ratio of water to the sum of the cement plus k times the addition, or

— by replacing the term “cement” with “effective cementitious material”, which is the sum of the cement plus k times the addition.

Guidance for the application of the k-value concept together with Portland cement (clinker content $>$ 95 %) is given in the following clauses. The k-value concept may be applied to type II additions with other cement types if there is established suitability in the place of use.

Other concepts, other k values, other additions (including type I) or combinations of additions may be given in the national annex.

NOTE The k value expresses the effectiveness of the type II addition as replacement for Portland cement with respect to the exposure condition or deterioration mechanism under consideration. Typical values are given as recommended values in this annex.

F.2 k-value concept for silica fume conforming to a standard valid in the place of use

The maximum amount of silica fume that can be taken into account for the k-value concept should meet the requirement that the ratio of silica fume to cement be less than 0,11 by mass.

If a greater amount of silica fume is used, the excess should not be taken into account for the k-value concept.

The following k values are recommended for concrete containing Portland cement:

— for specified water/cement ratio of $\leqslant$ 0,45 $k = 2{,}0$;

— for specified water/cement ratio of $>$ 0,45 $k = 1{,}0$.

The national annex should give the minimum amount of the sum of the cement plus k times the amount of silica fume depending on the exposure class.

F.3 k-value concept for fly ash conforming to a standard valid in the place of use

The maximum amount of fly ash that can be taken into account for the k-value concept should meet the requirement that the ratio of fly ash to cement be less than 0,33 by mass.

If a greater amount of fly ash is used, the excess should not be taken into account for the k-value concept.

The following k-values are recommended for concrete containing Portland cement:

— cement strength class of 32,5 $k = 0{,}2$;

— cement strength class of 42,5 and higher $k = 0{,}4$.

The national annex should give the minimum amount of the sum of the cement plus k times the amount of fly ash depending on the exposure class.

F.4 k-value concept for ground-granulated blast-furnace slag (GGBS) conforming to a standard valid in the place of use

The maximum amount of ground-granulated blast-furnace slag (GGBS) to be taken into account for the k-value concept should meet the requirement that the ratio of ground-granulated blast-furnace slag (GGBS) to cement be less than 0,6 by mass.

If a greater amount of ground-granulated blast-furnace slag (GGBS) is used, the excess should not be taken into account for the k-value concept.

The k values for use in a country may be given in a national annex, the k value should reflect the deterioration mechanisms of concern.

NOTE 1 Deterioration mechanisms are defined by the exposure classes in ISO 22965-1:2007, Table A.1. Slag is known to have a very good effect with respect to chloride ingress, while the effect with respect to carbonation is not considered equivalent to that of Portland cement on the basis of an equal water ratio.

Concrete with a high slag content can, after the surface concrete is carbonated, show unsatisfactory behaviour when exposed to freezing and thawing actions; when using a slag content higher than the ratio limit of 0,6, adequate freezing and thawing resistance should be documented.

The national annex should give the minimum amount of the sum of the cement plus k times the amount of ground-granulated blast-furnace slag (GGBS) depending on the exposure class.

Annex G
(informative)

Guidance on the national annex

The national annex should include the following:

a) any additional or deviating requirements for production control; see Clause 7;

b) alternatives to International Standards; see Clause 2;

c) limits for definition of high-strength concrete; see 3.5 and Clause A.6;

d) the volume of concrete for definition of a production day; see 3.8 and 9.2;

e) whether the following statement is true; see 5.1:

"Constituent materials that conform to the relevant International Standards cited in this national annex shall be deemed to meet the requirement that they do not contain harmful ingredients in such quantities as can be detrimental to the durability of the concrete or cause corrosion of the reinforcement provided that the concrete conforms to any specified limits placed on it, e.g. maximum chloride content."

f) constituent materials with general suitability for use in concrete; see 5.2 to 5.6;

g) maximum amount of undivided, recovered aggregate that can be added to the stockpile; see 5.4.2;

h) if not covered in the mixing water standard, provisions for the use of recycled water; see 5.5;

i) minimum quantity of admixture and the maximum volume of admixture before it is required to be taken into account in the calculation of the water/cement ratio; see 5.6;

j) requirements for the use of additions (see 6.1.1 and 6.1.3), i.e.

— other concepts or k values when using type II additions,

— minimum (sum of the cement plus k times the amount of addition) when using the k-value concept;

k) requirements for resisting damaging alkali-aggregate reaction; see 6.1.2;

l) method of measuring the slump or flow if not to the highest point; see 6.2.1;

m) provisions for adding admixtures or water on site to bring the consistence to the specified values; see 6.2.1;

n) measure of air content of light-weight concrete; see 6.2.3;

o) limits for oven-dry density of normal-weight concrete; see 6.3.3;

p) locally agreed relationship between a local test method or variation on a test method and the reference test method; see 7.3;

q) provisions for compliance to performance-related requirements (test method and compliance criteria), if any; see 5.4, Note 2, and 9.1;

r) minimum rates of sampling; see 9.2;

s) compliance criteria for an individual batch; see 9.3 and Annex E;

t) fixed margin for group-of-three non-overlapping results; see 9.4.2;

u) requirements for certification, if any; see 10.2;

v) margin for standardized prescribed concrete; see 9.4;

w) requirements for the qualifications of staff used for the production of concrete, if any; see A.3.1;

x) accuracy requirements for weighing equipment; see A.3.2.2;

y) batching tolerances; see Clause A.4;

z) compressive strength classes that divide normal concrete from high-strength concrete; see Clause A.6;

aa) delivery ticket, including declaration or certificate of compliance; see Table A.3;

bb) where designations have been used in ISO 22965-1 for the specification of concrete, the specification associated with these designations, e.g. for standardized prescribed concrete;

cc) test methods for the following:

- maximum aggregate size; see 5.4,
- acid-soluble sulfate content of light-weight aggregate; see 5.4,
- loss-on-ignition of light-weight aggregate; see 5.4,
- where required, freezing and thawing resistance of aggregates; see 5.4,
- chloride content of aggregate; see national annex,
- chloride content of admixture; see national annex,
- water absorption of normal-weight and heavy-weight aggregate; see 6.2.2.

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1) Under preparation.

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